CLAIMS

What is claimed is:

1. A method for detecting fluorescence emitted by cells in a wall of a body lumen, comprising the steps of:

   a. introducing an autonomous solid support into a body lumen;

   b. illuminating cells in a lumen wall of the body lumen from a light source mounted to the solid support with a wavelength that excites a particular fluorescent signal;

   c. detecting at a detector mounted to the solid support whether illuminated cells illuminated during step b emit the particular fluorescent signal; and

   d. if the particular fluorescent signal is detected from the illuminated cells, then determining at least one of an intensity and a position in the lumen wall of the detected fluorescent signal.

2. The method as recited in claim 1, further comprising generating an image that indicates positions in the lumen wall where the particular fluorescent signal is detected.

3. The method as recited in claim 1, wherein the particular fluorescent signal is emitted by a molecule that is endogenous to certain cells in the lumen wall.

4. The method as recited in claim 1, wherein:

   the method further comprises introducing to cells in the lumen wall including the illuminated cells, an exogenous fluorescent-labeled probe that binds to or is internalized by certain cells in the lumen wall; and

   the particular fluorescent signal is emitted by the exogenous probe.

5. The method as recited in claim 1, wherein the detected fluorescent signal indicates the presence or absence of abnormal cells.

6. The method as recited in claim 1, wherein the lumen wall is an intestinal wall and the abnormal cells are at least one of cancer cells, colon polyps and precancerous cells.

7. The method as recited in claim 4, said step of introducing the exogenous fluorescent-labeled probe comprising selecting the exogenous probe from a group comprising 2-deoxyglucose, Annexin V, phosphonium cations, rhodamine-123, JC1, and TMRE.

8. The method as recited in claim 4, said step of introducing the exogenous fluorescent-labeled probe comprising labeling an exogenous probe with a fluorescent marker that is a member of a group comprising 5-carboxyfluorescein diacetate, succinimidyl ester (CFDA/SE), 6-carboxyfluorescein diacetate, Aequorea green fluorescent protein (GFP), a two-photon fluorophore (C625), red fluorescent protein (dsRed) from discosoma (coral), cyanine dye, 3,3-diethylthiadicarbocyanine, carboxyfluorescein diacetate succinimidyl ester (CFSE), intrinsically fluorescent proteins Coral red (dsRed) and yellow (Citrine), fluorocein, rhodamine 123, Sulforhodamine (red), Dinitrophenyl (yellow), Dansyl (yellow) and safranin O

9. The method as recited in claim 4, said step of introducing the exogenous fluorescent-labeled probe to cells in the lumen wall further comprising injecting the exogeneous probe into the animal.

10. The method as recited in Claim 4, said step of introducing the exogenous fluorescent-labeled probe to cells in the lumen wall comprises releasing the exogenous fluorescent-labeled probe from a reservoir on the solid support.

11. The method as recited in Claim 10, further comprising, before said step of illuminating the cells in the lumen wall, performing the step of emitting ultrasonic waves from a sound source on the solid support to enhance uptake of the exogenous probe.

12. The method as recited in Claim 10, further comprising, before said step of illuminating the cells in the lumen wall, performing the step of generating an electric field from an electrode on the solid support to enhance uptake of the exogenous probe.

13. A method for detecting fluorescence emitted by intestinal cells *in vivo*, comprising the steps of:

a. introducing an autonomous solid support into the lumen of the intestine;

b. illuminating cells in the intestine wall from a light source mounted to the solid support with a wavelength that excites a particular fluorescent signal;

c. detecting at a detector mounted to the solid support whether illuminated cells illuminated during step b emit the particular fluorescent signal; and

d. if the particular fluorescent signal is detected from the illuminated cells, then determining at least one of an intensity and a position in the intestine of the detected fluorescent signal.

14. A method for killing abnormal cells in the intestinal tract of an animal, comprising the steps of

a. administering to the animal an exogenous fluorescent-labeled probe that is selectively internalized by or binds to abnormal intestinal cells;

b. introducing an autonomous solid support into the lumen of the intestine;

c. illuminating cells in the intestinal wall from a light source mounted to the solid support with a wavelength that excites a particular fluorescent signal emitted by the fluorescent label on the exogenous probe;

d. detecting at a detector mounted to the solid support whether illuminated cells illuminated during step b emit the particular fluorescent signal; and

e. if the particular fluorescent signal is detected, then releasing a drug that kills the abnormal intestinal cells.

15. The method as recited in claim 14, wherein the abnormal cells are at least one of cancer cells, colon polyps or precancerous cells.

16. The method as recited in claim 14, said step of releasing the drug that kills the abnormal cells comprises releasing the drug from a reservoir on the solid support introduced into the lumen of the intestine.

17. The method as recited in claim 14, said step of releasing the drug that kills the abnormal cells comprises releasing the drug from a reservoir on a different solid support introduced into the lumen of the intestine.

18. The method as recited in Claim 14, further comprising the step of emitting ultrasonic waves from a sound source on the solid support to enhance uptake of the drug.

19. The method as recited in Claim 10, further comprising the step of generating an electric field from an electrode on the solid support to enhance uptake of the drug.

20. A method for killing abnormal cells in the intestinal tract of an animal, comprising the steps of

a. administering to the animal an amount of one or more exogenous probes that is selectively internalized by or binds to abnormal intestinal cells, wherein the at least one probe is bound to a fluorescent label and at least one probe is bound to a light-activated toxin;

b. introducing an autonomous solid support into the lumen of the intestine;

c. illuminating cells in the intestinal wall from a light source mounted to the solid support with a wavelength that excites a particular fluorescent signal emitted by the fluorescent label on the exogenous probe;

d. detecting at a detector mounted to the solid support whether illuminated cells illuminated during step b emit the particular fluorescent signal; and

e. if the particular fluorescent signal is detected, then illuminating the cells with light to activate the light-activated toxin to kill the abnormal cells.

21. The method as recited in claim 20, said step of administering the amount of one or more exogenous probes further comprising selecting the exogenous probe from a group comprising hematoporphyrin, 5-aminoluvulinic acid (ALA), photofrin, polyhematoporphyrin, and mesotetrahydroxyphenylchlorin.

22. A method for determining the efficacy of treatment of cancer in the upper and lower intestinal tract in an animal comprising the steps of

a. administering to the animal having cancer of the upper or lower intestinal tract an amount of an exogenous fluorescent-labeled probe that is selectively internalized or bound by the cancer cells;

b. illuminating cells in the intestinal wall from a light source mounted to a first autonomous solid support introduced into the lumen of the intestine with a wavelength that excites a particular fluorescent signal emitted by the fluorescent label on the exogenous probe in the cancer cells;

c. detecting at a detector mounted to the first solid support the fluorescent signal emitted by the exogenous probe in cancer cells illuminated during step b to determine a first amount of fluorescent emission;

d. after step c, administering treatment to the animal having cancer of the upper or lower intestinal tract to eliminate the cancer cells;

e. after step d, administering to the animal an amount of the exogenous fluorescent-labeled probe;

f. illuminating cells in the intestinal wall from a light source mounted to a second autonomous solid support introduced into the lumen of the intestine with the wavelength that excites the particular fluorescent signal;

g. detecting at a detector mounted to the second solid support the fluorescent signal emitted by the exogenous probe in cancer cells illuminated during step f to determine a second amount of fluorescent emission; and

h. determining an efficacy of the treatment based on a difference between the first and second amounts of fluorescent emission.

23. The method as recited in claim 22, wherein the first solid support is the same as the second solid support.

24. The method as recited in claim 22, wherein the first solid support is different from the second solid.

25. A capsule for detecting fluorescence emitted by cells in a wall of a body lumen in an animal, comprising:

a solid support that fits inside a body lumen;

a light source mounted to the solid support for generating light with a wavelength that excites a particular fluorescent signal in certain molecules;

a first optical element mounted to the solid support for illuminating a section of a lumen wall of the body lumen with light from the light source;

a detector mounted to the solid support for generating measurements based on the particular fluorescent signal;

a second optical element mounted to the solid support for directing onto the detector the particular fluorescent signal emitted from the section illuminated; and

a data transfer system for transferring data based on the measurements to a monitoring unit outside the animal.

26. The capsule as recited in Claim 25, the second optical element further comprising a filter to block out light at wavelengths not part of the particular fluorescent signal.

27. The capsule as recited in Claim 25, the second optical element further comprising a shutter to block out light at times when the light source is illuminated.

27. The capsule as recited in Claim 25, wherein the illuminated section is a band along an inner circumference of the body lumen.

28. The capsule as recited in Claim 27, the first optical element further comprising a transparent band in an outer cover of the solid support.

29. The capsule as recited in Claim 28, the first optical element further comprising an axicon to convert a light pulse on an axial beam from the light source into a radial band of light that passes through the transparent band.

30. The capsule as recited in Claim 28, the first optical element further comprising a coherent bundle of optical fibers that cause a light pulse on an axial beam from the light source to diverge to multiple radial beams of light that pass through the transparent band.

31. The capsule as recited in Claim 28, the first optical element further comprising a rotating mirror that reflects a light pulse on an axial beam from the light source to a rotating radial beam that passes through the transparent band.

32. The capsule as recited in Claim 25, wherein the first optical element prevents light of the light source from impinging on the detector.

33. The capsule as recited in Claim 28, the second optical element further comprising an axicon to convert a band of light that passes through the transparent band from the illuminated section of lumen wall to one or more beams of light that strike the detector.

34. The capsule as recited in Claim 28, the second optical element further comprising a coherent bundle of optical fibers that causes multiple radial beams of light that pass through the transparent band from the illuminated section of the lumen wall to converge on the detector.

35. The capsule as recited in Claim 28, the second optical element further comprising a rotating mirror that reflects in turn multiple radial beams of light that pass through the transparent band from the illuminated section of the lumen wall onto the detector.

36. The capsule as recited in Claim 25, the detector further comprising a single sensor that integrates light in the particular fluorescent signal over the whole illuminated section.

37. The capsule as recited in Claim 25, the detector further comprising an array of sensors that distinguishes light intensity in the particular fluorescent signal among different portions of the illuminated section.

38. The capsule as recited in Claim 25, the detector further comprising a sensor that distinguishes light intensity in the particular fluorescent signal from the illuminated section among different times after the light source has stopped illuminating the section.

39. The capsule as recited in Claim 25, the data transfer system further comprising a processor to generate pixels for an image based on the measurements.

40. The capsule as recited in Claim 39, each pixel representing an intensity of the particular fluorescent signal integrated over the illuminated section.

41. The capsule as recited in Claim 39, each pixel representing an intensity of the particular fluorescent signal for one portion of the illuminated section.

42. The capsule as recited in Claim 25, further comprising.

a reservoir for storing at least one of an exogenous fluorescent-labeled probe and a drug for killing abnormal cells; and

a release mechanism to release contents of the reservoir upon command.

43. The capsule as recited in Claim 42, further comprising an electrode for generating an electric field to enhance uptake of the contents of the reservoir by cells in the lumen wall after release of the contents.

44. The capsule as recited in Claim 42, further comprising an acoustic transducer for generating acoustic waves to enhance uptake of the contents of the reservoir by cells in the lumen wall after release of the contents.

45. The capsule as recited in Claim 25, further comprising at least one of a navigating system and a wireless power transfer system.

46. The capsule as recited in Claim 25, further comprising a position control system for working against peristaltic action by the walls of the lumen on the solid support.

47. A monitoring unit for presenting fluorescence emitted by cells in a wall of a body lumen in an animal, comprising:

a receiver for receiving data from a capsule that fits inside a body lumen, the capsule including:

a solid support,

a light source mounted to the solid support for generating light with a wavelength that excites a particular fluorescent signal in certain molecules,

a detector mounted to the solid support for generating measurements based on the particular fluorescent signal emitted by an illuminated section of the lumen wall, and

a data transfer system for transferring data based on the measurements to the receiver; and

a processor to generate an image based on the data; and

a display for presenting the image to a user.

48. The monitoring unit as recited in Claim 47, wherein

the receiver is configured to obtain position measurements based on a position of the capsule in the body lumen; and

the processor is configured to determine the position of the capsule based on the position measurements from the receiver.

49. The monitoring unit as recited in Claim 47, wherein:

the fluorescent signal is emitted by an exogenous fluorescent-labeled probe that is selectively internalized by or binds to abnormal cells in the lumen wall;

the capsule includes

a reservoir for storing at least one of an exogenous fluorescent-labeled probe and a drug for killing abnormal cells,

a release mechanism to release contents of the reservoir upon command, and

a capsule receiver for receiving the command;

the processor is configured to determine when to release the contents of the reservoir; and

the monitoring unit further comprises a transmitter to transmit the command to the capsule receiver.

50. A system for detecting fluorescence emitted by cells in a wall of a body lumen in an animal, comprising:

a capsule including

a solid support that fits inside a body lumen,

a light source mounted to the solid support for generating light with a wavelength that excites a particular fluorescent signal in certain molecules,

a detector mounted to the solid support for generating measurements based on the particular fluorescent signal emitted from an illuminated section of the body lumen, and

a data transfer system for transferring data based on the measurements; and

a monitoring unit including

a receiver for receiving the data from the capsule,

a processor to generate an image based on the data, and

a display for presenting the image to a user.